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TECHNICAL report

USA-BRDEC-TR // 2504

Engineering Evaluation of the MEMTEC, Limited, Small Reverse Osmosis Water Purification Unit (ROWPU) for the United States Southern Command

Prepared by
Terence A. Willoner

Report Date
April 1991

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United States Army
Belvoir Research, Development and Engineering Center
Fort Belvoir, Virginia 22060-5606

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	April 1991	Final

4. TITLE AND SUBTITLE

Engineering Evaluation of the MEMTEC, Limited, Small Reverse Osmosis Water Purification Unit (ROWPU) for the United States Southern Command (U)

5. FUNDING NUMBERS

6. AUTHOR(S)

Terence A. Willoner

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Belvoir Research, Development and Engineering Center
Fuel and Water Quality Team, Fuel and Water Supply Division
Logistics Equipment Directorate
Fort Belvoir, VA 22060-5606

8. PERFORMING ORGANIZATION REPORT NUMBER

2504

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

POC: Terence Willoner, 703/664-5746

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Distribution unlimited; approved for public release.

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)

This report describes the engineering evaluation of the MEMTEC, Limited, Small Reverse Osmosis Water Purification Unit (ROWPU). The objectives of the Engineering Evaluation were to: (1) Determine if the MEMTEC Small ROWPU met Quality Assurance acceptance criteria listed in contract DAAK70-89-C-0076, Section E.1.1; (2) Provide the opportunity for the Project engineer and support personnel to obtain a working knowledge of the Small ROWPU's operational characteristics prior to the operational test at the Tropic Test Site, Panama; and (3) Accrue operating hours on the Small ROWPU system under semi-controlled conditions to provide an opportunity to correct any operational glitches prior to initiating TTS operational testing.

14. SUBJECT TERMS

Continuous micro-filtration (CMF) module; sprial would RO membrane element; propylene glycol

15. NUMBER OF PAGES

54

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

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Fort Belvoir, Virginia 22060-5606

April 1991

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ACKNOWLEDGEMENTS

The evaluation covered by this report was conducted by the Fuel and Water Quality Team, Fuel and Water Supply Division, Logisitics Equipment Directorate, US Army Belvoir Research, Development, and Engineering Center (Belvoir). The effort was funded by Headquarters, Army Materiel Command (HQ, AMC), Office for International Cooperative Programs, Aberdeen Proving Ground, MD.

This project was accomplished under the general direction of Winfred E. Lindley, Chief, Fuel and Water Quality Team.

The engineering evaluation was conducted by the following Belvoir personnel:

Mr. Terence A. Willoner, Principal Project Engineer
Mr. Tom E. Warren, General Engineer
Mr. Eddie Blake, Engineering Technician
SGT Donald A. Roberts, Water Treatment NCO
Mr. Eric Doak, Engineering Student
Mr. Kenny Garner, Engineering Technician
Mr. Patrick Shields, Engineering Technician

The assistance and general direction from Mr. Joseph Andrese and Ms. Patricia Nunn, HQ, AMC Office for International Cooperative Programs, is appreciatively acknowledged.

The assistance of Ms. Doris Tribolet, Belvoir International Programs Office, is also acknowledged.

SECTION I
INTRODUCTION

BACKGROUND

The US Southern Command (SOUTHCOM) has a requirement for a Small Reverse Osmosis Water Purification Unit (ROWPU) to support small task forces throughout Latin America to perform a variety of assistance missions, such as disaster relief, search and rescue, road building, and counter-narcotic support. The SOUTHCOM Request for Water Purification Support and the approved Operational Needs Statement (ONS) are at Appendix A.

In November 1987, the Water Technology R&D Team of the Belvoir Research, Development and Engineering Center (Belvoir) was briefed on the problems SOUTHCOM was experiencing with water purification equipment. Currently, the water purification equipment used to support SOUTHCOM's deployed theater task forces consisted of borrowed assets from Continental United States units, specifically the 600 gallon per hour (gph) ROWPU, which far exceeds the needs of a single task force. Furthermore, these current systems require a single C-130 aircraft to transport the unit, personnel, and supplies to the area of operation. Minimum cost for this airlift is $24,000. Moreover, the availability of support personnel, equipment, and supplies to maintain water production with a 600 gph ROWPU is often a problem for SOUTHCOM task forces.

SOUTHCOM requested approval from Headquarters, Department of Army (HQDA) of an ONS for a Small ROWPU. The ONS was approved 16 June 1988 and was designated as a Quick Reaction Program. In addition, the approval letter directed Headquarters, Army Materiel Command (HQAMC) to evaluate candidate Small ROWPUs for SOUTHCOM.

In order to provide earliest possible water purification capability to SOUTHCOM, Belvoir conducted a market investigation to identify manufacturers capable of supplying a ROWPU in accordance with the requirements stated in the SOUTHCOM ONS. Belvoir combined its market investigation results with those obtained during a market investigation conducted for SOUTHCOM by the BDM Corporation in 1987, and proceeded to initiate a competitive procurement action to obtain one commercially available "off-the-shelf" Small ROWPU from a domestic manufacturer. The winning offeror, MEMCOR, Inc., Baltimore, MD, was selected on the basis of best technical approach and lowest cost.

It is noteworthy that the MEMCOR Small ROWPU was found to most closely meet the SOUTHCOM ONS requirements, as compared to other domestic ROWPUs, but none of the domestic units met all requirements. The MEMCOR ROWPU was provided to the Tropic Test Site (TTS),

Republic of Panama, in May 1989 for troop training and operational evaluation. The TTS operational evaluation confirmed that the domestic Small ROWPU could not meet SOUTHCOM requirements. The most critical shortfalls were in system weight and operability. The operational evaluation of the domestic Small ROWPU was discontinued in July 1989 due to political unrest in Panama which led to partial withdrawal of personnel from the TTS and eventually culminated in *Operation Just Cause* in December 1989.

Having recognized that no domestic manufacturer was capable of offering a unit which fully met the stated requirements, Belvoir initiated a parallel action to obtain funding for evaluation of foreign military Small ROWPUs meeting the SOUTHCOM requirements. Funding was obtained through the Foreign Weapons Evaluation Program. This funding was used for the procurement of four Small ROWPUs: two from Stella-Meta Filters, Whitchurch, England; and two from MEMTEC, Limited, South Windsor, Australia. The two MEMTEC ROWPUs were received at Belvoir in February 1990 for training, engineering evaluation, and shipment to Panama for operational testing.

This report describes the engineering evaluation of the MEMTEC Small ROWPU. For information concerning the Stella-Meta Small ROWPU, see Belvoir technical report, *Engineering Evaluation of the Stella-Meta Small Reverse Osmosis Water Purification Unit for United States Southern Command*, to be published in Spring/Summer 1991.

OBJECTIVES

The objectives of this Engineering Evaluation were to:

1 Determine if the MEMTEC, Limited, Small ROWPUs met Quality Assurance acceptance criteria listed in contract DAAK70-89-C-0076, Section E.1.1 (see Appendix B for excerpt from contract);

2 Provide an opportunity for the Project Engineer and support personnel to obtain a working knowledge of the Small ROWPU's operational characteristics prior to the operational test at the TTS, Panama; and

3 Accrue operating hours on the Small ROWPU system under semi-controlled conditions to provide an opportunity to correct any operational glitches prior to initiating TTS operational testing.

This engineering evaluation was not intended to serve as an operational test of the MEMTEC Small ROWPU's ability to purify water to meet drinking water standards. For results of the Small ROWPU's performance in purifying water to meet drinking water standards, see document No. DPG-TR-90-220B, The US Army Test and Evaluation Command project number 8-ES-225-00-007, Dugway Proving Ground, UT.

DESCRIPTION OF EQUIPMENT

The MEMTEC Small ROWPU system is a ROWPU having a net potable water production of 30 gph on seawater and 90 gph on freshwater. The units supplied were MEMTEC model number 100 LPHSW, Serial No. 89-5006 (Unit 1) and Serial No. 89-5007 (Unit 2). The MEMTEC Small ROWPU is intended to be capable of operation on freshwater (0 to 1,500 parts per million (ppm) Total Dissolved Solids (TDS)), brackish water (1,501 to 15,000 ppm TDS), or seawater (15,001 to 35,000 ppm TDS) sources. The MEMTEC Small ROWPU is intended to operate on power supplied by one standard military 3 kilowatt (kW) generator. Figure 1 depicts a schematic of the MEMTEC Small ROWPU system. The unit is configured in three separate sections or subsystems consisting of the following:

- **Freshwater System:**

Continuous Micro-Filtration Module	120 lb
Air compressor	145 lb
Storage box	375 lb
Control panel	90 lb

- **Desalination Unit:**

Reverse Osmosis (RO) Skid	150 lb

- **Storage and Distribution System:**
  500 gal fabric tank (with separate storage box)

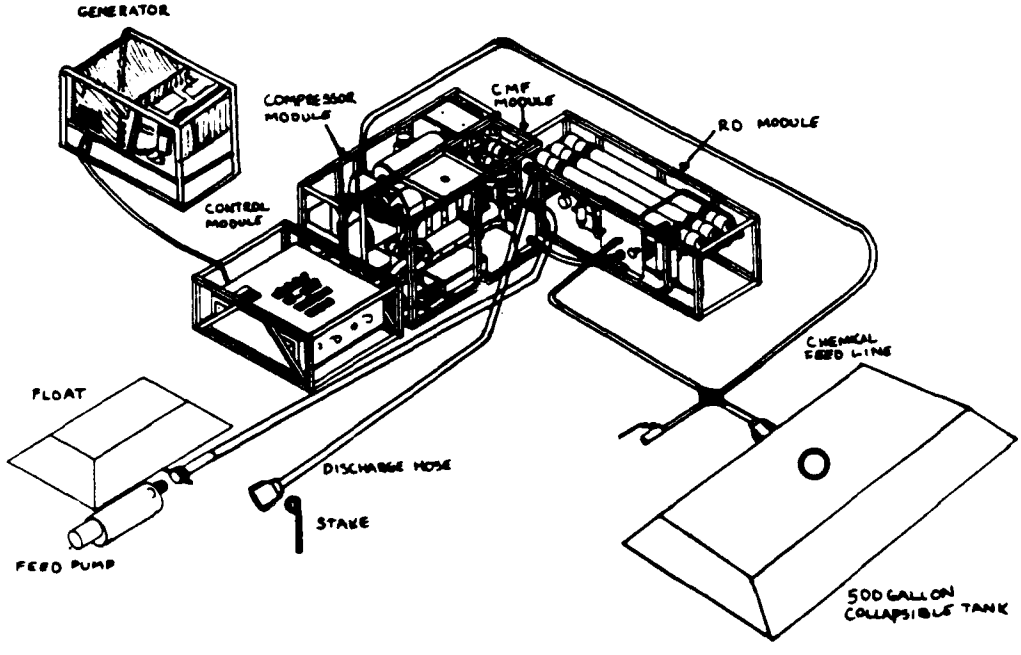

Figure 1. Schematic of the MEMTEC Small ROWPU

Also included is a precision dosing pump which is used as a chlorine sterilization dosing package to disinfect the product water when the unit is operating from freshwater, brackish water or seawater.

The storage and distribution system includes one 500 gallon food quality fabric pillow tank. Distribution is accomplished via gravity feed through a potable water quality hose.

Table 1 contains a list of accessories which were delivered with the unit.

The unit was also delivered with commercial operational/maintenance manuals. The contractor provided 1 week of training to the principal Project Engineer and the test and evaluation staff on the operation and maintenance of the water purification unit.

Table 1. MEMTEC Small ROWPU Accessories

Item	Quantity
25-foot raw water hose	1
Submersible pump/suction strainer	1
Suction strainer float	1
10-foot product hose	1
Chlorine measurement instrument	1
pH measurement instrument	1
TDS measurement instrument	1
Chemical mixing tank	1
Set of spare parts for 1,000 operating hours	1

SECTION II
OPERATING PROCEDURES

Throughout the Engineering Evaluation, the MEMTEC Small ROWPU was operated in accordance with the commercial operational/maintenance manual. The operating sequences of the MEMTEC Small ROWPU for both water production and backwashing are monitored and controlled by a factory-programmed microprocessor. The MEMTEC Small ROWPU system operations for water production and backwashing are described below.

WATER PRODUCTION

Unfiltered water is pumped from the raw water source and through a flexible suction hose to the hollow fiber Continuous Micro-Filtration (CMF) module. Large particles are removed by a 140 micron strainer before the feed stream enters the hollow fiber filter cartridge bank. A portion of this feed stream is cleaned by passing through the membrane walls and then it flows out of the system as filtrate (see Figure 2). The portion of the feed stream that does not pass through the membrane is rejected through a discharge hose. As the filtrate exits the CMF module, it passes to the reverse osmosis (RO) module, if the RO module is on line. For freshwater purification, the RO module may be removed from the system. A high pressure pump forces the filtrate into the RO membrane elements where dissolved solids are removed. The MEMTEC Small ROWPU RO module consists of three 2.5-inch spiral wound thin film composite RO membrane elements (see Figure 3). The reject (brine) from the membrane is discharged and directed back to the CMF module where it is commingled with the filter reject stream and returned to the raw water source. The filtrate leaving the RO module is disinfected by a chemical feed pump injecting dosages of disinfectant. The disinfectant is stored in the Compressor and Dosing Module. The disinfected product water is then fed to the collapsible fabric tank for storage and distribution.

OPERATING MODE

The feed stream is pumped into the cartridge shell and passes over the fiber walls. Some liquid filters through the walls and exits the cartridge as clean filtrate. The remaining feed and rejected waste flows across the fiber wall as concentrate and exits through the shell outlet.

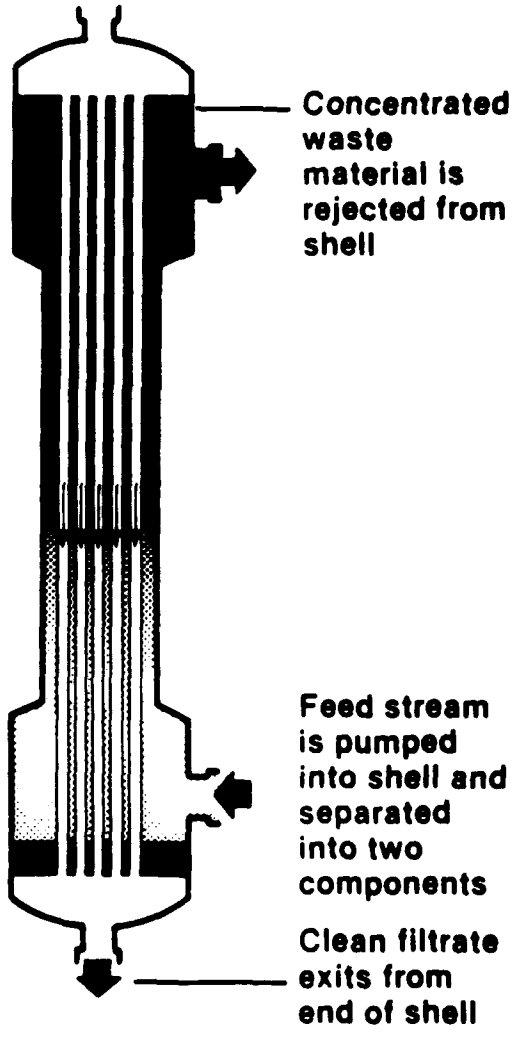

Figure 2. Continuous Micro-Filtration Module

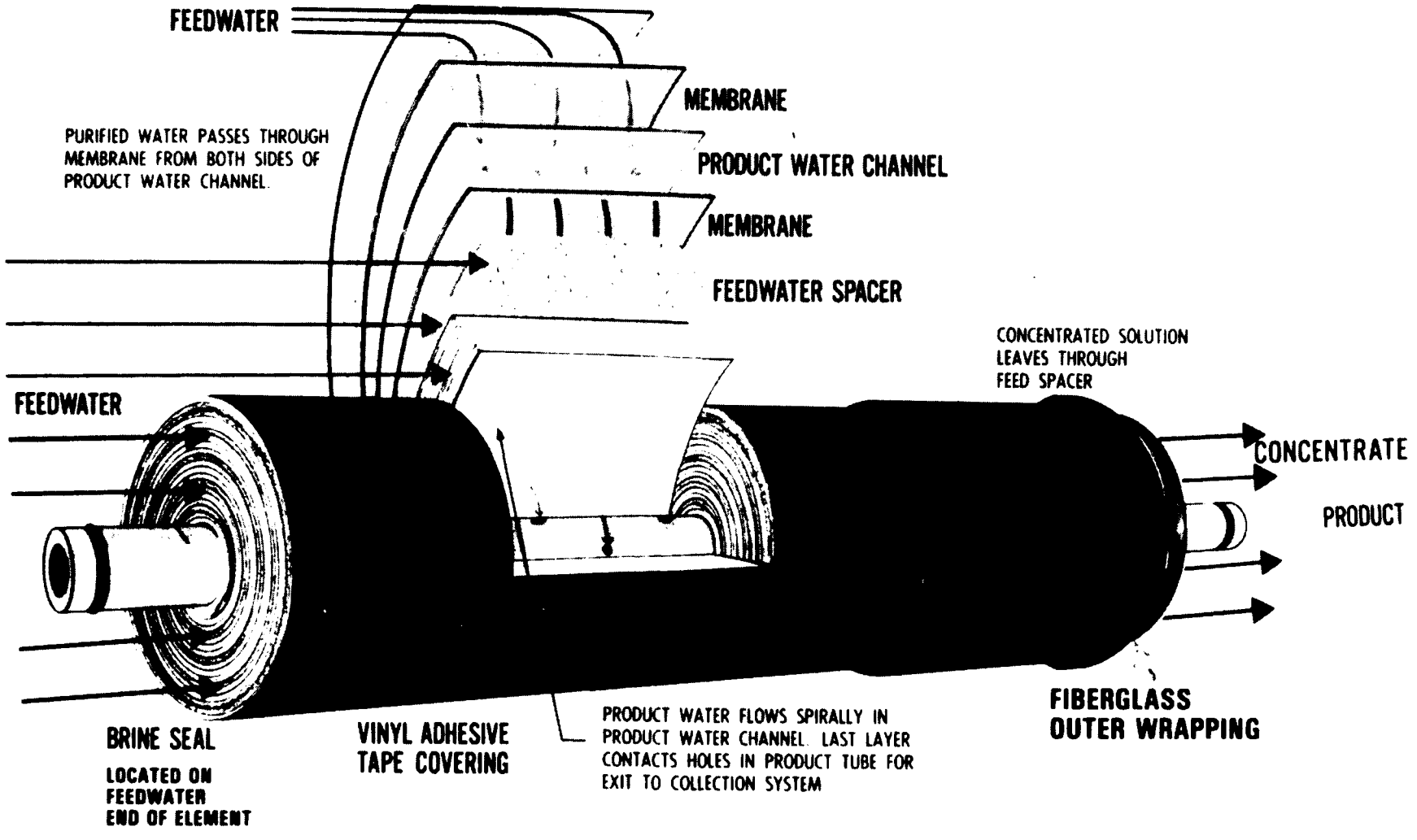

Figure 3. Spiral Wound Reverse Osmosis Membrane Element

BACKWASHING

Contaminants which become trapped in the pores of the hollow fiber membranes are periodically removed during the automatic backwash cycle. Air supplied by an air compressor in the Compressor and Dosing Module enters the CMF module and drains the fibers. The drained liquid exits the CMF module and is carried away by discharge hose. Next, the insides of the fibers are pressurized with air, and a blast of air is released which drives the accumulated debris off of the fiber walls. Crossflow is resumed and normal filtration continues.

SECTION III
ENGINEERING EVALUATION DISCUSSION AND RESULTS

The Engineering Evaluation was divided into four tests, including a 6-hour Quality Assurance Test, a 5-day Seawater Test, a 5-day River Test, and a 5-day Pond Test. Appendix C contains testing photographs. Each test was conducted at the US Army Belvoir Research, Development and Engineering Center (Belvoir) during the following dates:

Quality Assurance Test:	2 - 5 February 1990 (Units 1 and 2)
Seawater Test:	12 - 16 February 1990 (Unit 1)
River Test:	20 - 23 February 1990 (Unit 1)
Pond Test:	26 - 28 February 1990 (Unit 2)

Due to the inaccurate flow gauges located on the MEMTEC Small ROWPU, an accurate external flow meter was used to measure the product flow rate. The flow rate recorded from this flow meter was multiplied by a factor to get a result of gallons per hour, and is reported as "CALCULATED PRODUCT FLOW." This accurate flow rate was then normalized to temperature and raw water TDS for the tests which included the RO section. A flow totalizer was also added to the test loop to record the total product water produced by the Small ROWPU.

QUALITY ASSURANCE TEST (6 hours)

Prior to any operational training, the 6-hour ality Assurance Test was conducted on both Units 1 and 2, of the MEMTEC Small ROWPUs. The Quality Assurance Test required that the ROWPUs be hydraulically tested using seawater (35,000 TDS at 25°C) for not less than 6 hours. Evidence of any of

the conditions listed below would have been cause for failure of the Quality Assurance Test:

- leaks at any weld seam or connection
- failure of any switch or light to operate
- failure of valves to operate properly
- mechanical or electrical failures with any part.

The Quality Assurance Test was conducted in Belvoir's Reverse Osmosis Element Test Room, Building 325. The test room is heated and has an exhaust fan for cooling. Each MEMTEC Small ROWPU was powered by one 3 kW military standard gasoline generator. The generators were located outside the building, and cables from the generators were led to the ROWPUs through an aperture in the building wall. Synthetic seawater was used for the Quality Assurance Test. The temperature of the seawater was not controlled by a heat exchanger. When the temperature in the test room exceeded 90°F, the exhaust fan was activated and ice was added to the seawater.

The Quality Assurance Test was conducted in the presence of MEMTEC representatives who assisted the Project Engineer in the operation of the Small ROWPU. Pre-test inspection revealed that the computer program which controls the backwashing operation sequencing contained a programming error which manifested itself by causing continuous backwashing during the chemical cleaning process. MEMTEC modified the program prior to the start of the Quality Assurance Test to correct this problem. During the initial start-up of the test, the air compressor in one unit would not build up pressure. Following disassembly and inspection, dirt was found to be blocking a check valve in the assembly. Once the check valve was cleaned, no further problems with compressor operations were noted.

During the 6-hour operation, the ROWPU was examined and inspected. No leaks at weld seams or connections were detected. The lights, switches, and valves operated successfully with the exception of the check valve, as described above. No mechanical or electrical failures occurred.

SEAWATER TEST

The 5-day Seawater Test conducted on Unit 1 was designed to achieve the following objectives:

- evaluate equipment operation characteristics during a typical mission time period;
- gain an understanding of probability of membrane fouling, operating pressures, flow rates, and membrane element life expectancy when operating on seawater; and
- determine the ROWPU system's material compatibility with corrosive seawater.

The 5-day Seawater Test was conducted in Belvoir's RO Element Test Room, Building 325, with the same feed water and under the same environmental conditions as those for the Quality Assurance Test.

During the Seawater Test, product water samples were collected hourly and tested for TDS, pH, and temperature. The operational data for the Seawater Test is at Appendix D. A summary of the data is shown in Table 2.

Table 2. Summary of Operations—Seawater Test

Parameter	Cumulative Total
Cumulative flow	1,228 gallons
Total unit operating time	42.8 hours
Total generator time	44.6 hours

Parameter	Seawater Test Average
Pressure gauge #5	732 psi
Brine flow FM2	2.0 gpm
Product flow FM3	0.3 gpm
Calculated product flow	30.7 gph
Normalized flow	44.1 gph
Pressure gauge #1	27 psi
Pressure gauge #3	27 psi
Microfilter delta pressure	0.0 psi
Product water TDS	311 ppm
Product water pH	7.3
Raw water TDS	34,998 ppm
Raw water pH	7.3
Raw water temperature	26.4°C

The ROWPU was successfully operated on seawater for a total of 42.8 hours. After 2 hours of operation, the unit automatically ceased water production and went into clean mode. It was found that an error in the computer program caused this condition. The manufacturer was notified and subsequently provided instructions to bypass this conditions so testing could continue. The unit was repaired 3 hours later by the manufacturer. The unit was put back into operation; however, it was noted that the air compressor was not shutting off after reaching the proper pressure. The unit was shut down to inspect the air compressor. Dirt was found in a check valve located on the air compressor. This condition was corrected and the unit was put back into operation. Dirt was then found to be clogging flow through the flow restrictor. This condition resulted in reduced output from the microfilters and thus cavitation of the high pressure pump. Once this problem was corrected, operations continued without incident, until the submersible pump experienced an internal short. The short resulted from exposure of the electrical connections to seawater despite the precautionary cover and sealant. This was considered a major design flaw and would be a recommended area for engineering improvements in future MEMTEC Small ROWPUs. There was also some corrosion of aluminum parts on the ROWPU as a result of contact with the seawater.

There were no indications of fouling of either the RO membrane elements or the microfilters. Increased pressure without recovery after cleaning or reduction in product water quality would be an indication of fouling.

RIVER TEST

The River Test was conducted on Unit 1 at Belvoir's Potomac River test site, Building T394. The Potomac River is considered to be a highly turbid, natural freshwater source similar in degree of suspended materials to the highly turbid rivers found in Central and South America. Arrival and departure of Army landing craft headed for a repair station located across the river from the ROWPU intake point increased the turbidity of the river water during the River Test. Rain, which fell for 3 of the 5 days of testing, also helped raise the river's turbidity.

The River Test was conducted with and without the RO module of the system on line. The unit in actual field conditions where freshwater is being treated may not, in many cases, be operated with the RO section. This modular design, which allows for unnecessary sections to be removed to save on space and weight demands, is a major advantage of the Small ROWPU.

Results of the River Test operations without the RO module are summarized in Table 3. The actual hourly operating data for the River Test without the RO module is at Appendix E. The actual hourly data for the River Test with the RO module in line is at Appendix F and is summarized in Table 4. The ROWPU was operated on the Potomac river for a total of 29.5 hours, with one incident accountable to the unit. Again, the flow restrictor became

clogged 23 hours into the test in a repeat of the incident experienced during the Seawater Test. MEMTEC representatives believed that the clogging agent was Teflon tape used on the piping joints. The flow restrictor was cleaned 6 hours after problems first occurred. The delay in cleaning the flow restrictor resulted from difficulties in locating the source of the problem.

During the entire River Test, a total of 1,160 gallons of water were produced. A second incident, found to be accountable to testing and not the unit itself, occurred after 9 hours of testing. The unit was taken into an unheated building for overnight protection from freezing. During the setup of unit and starting of the 3 kW generator, the impeller of the submersible pump was frozen in ice. Therefore, when the unit was started, the pump blew a fuse in the control panel.

Table 3. Summary of Operations—River Test Without RO

Parameter	Cumulative Total
Cumulative flow	668 gallons
Total unit time	11.8 hours
Total generator time	13.2 hours

Parameter	River Test Average (no RO)
Calculated product flow	57.1 gph
Pressure gauge #1	23 psi
Pressure gauge #3	22 psi
Microfilter delta pressure	1 psi
Product water TDS	123 ppm
Product water pH	7.4
Product turbidity	0.2 NTU
Raw water TDS	125 ppm
Raw water pH	7.4
Raw water turbidity	12.2 NTU
Raw water temperature	9.3°C

Table 4. Summary of Operations—River Test With RO

Parameter	Cumulative Total
Cumulative flow	492 gallons
Total unit time	17.7 hours
Total generator time	18.8 hours

Parameter	River Test Average (with RO)
RO gauge pressure	398 psi
Brine flow	1.8 gpm
Product flow FM3	0.27 gpm
Calculated product flow	30.3 gph
Normalized flow	68.1 gph
Pressure gauge #1	21 psi
Pressure gauge #3	20 psi
Microfilter delta pressure	1 psi
Product water TDS	4.5 ppm
Product water pH	7.9
Product turbidity	0.15 NTU
Raw water TDS	119 ppm
Raw water pH	7.1
Raw water turbidity	34 NTU
Raw water temperature	8.4°C

POND TEST

The Pond Test, conducted on Unit 2, was designed to provide evaluation of the Small ROWPU operations on a low turbidity, high organic content, freshwater source. This was conducted on a small lagoon, approximately 65,000 gallons, near Building 325. As a result of rainy, snowy, and windy weather, which caused disturbances in the pond, the turbidity of the pond water was higher than is normally expected for a stagnant pond.

As with the River Test, water production operations were conducted both with and without the RO module removed from the Small ROWPU system. The results of the Pond Test are listed in Tables 5 and 6, for operations without and with the RO module, respectively. The actual hourly data for the Pond Test without and with the RO module are at Appendices G and H, respectively. The ROWPU operated for a total of 45 hours, 27 of which were operations without the RO skid.

During the Pond Test, the outdoor temperature averaged 40°F, with a low of 26°F and a high of 50°F. At the start of the test, ice had formed on the pond; it was broken up prior to testing. During the second day of testing, snow was falling. The cold conditions caused a check valve to freeze which prevented backwashing. The check valve was cleaned; operations resumed shortly thereafter. To prevent the unit from freezing again, two small electric heaters were placed on either side of the unit and the entire assembly was covered. Each evening, the unit was taken inside the warm building; however, this did not help prevent the unit from freezing during setup the next morning.

Propylene glycol was recommended by the Water Technology R&D Team, Fuel and Water Supply Division, as a preservative and an antifreeze (see Material Safety Data Sheet Appendix I). After propylene glycol was flushed through the entire unit each evening, no further freezing problems were encountered.

As the final stage of testing, the chemical dosing pump was used to chlorinate the product water. The pump was operated for 15 hours at an average rate of 6.4 ppm. The pump was difficult to control; the steady rate required of 5 ppm was never maintained.

Table 5. Summary of Operations—Pond Test Without RO Skid

Parameter	Cumulative Total
Cumulative flow	2,337 gallons
Total unit time	27.0 hours
Total generator time	27.8 hours
Parameter	**Pond Test Average (no RO)**
Calculated product flow	89.5 gph
Pressure gauge #1	32 psi
Pressure gauge #3	32 psi
Microfilter delta pressure	0 psi
Product water TDS	29 ppm
Product water pH	5.7
Product turbidity	0.18 NTU
Raw water TDS	30 ppm
Raw water pH	6.2
Raw water turbidity	23.5 NTU
Raw water temperature	5.4°C

Table 6. Summary of Operations—Pond Test With RO Skid

Parameter	Cumulative Total
Cumulative flow	520 gallons
Total unit time	18.0 hours
Total generator time	18.9 hours
Parameter	**Pond Test Average (no RO)**
RO gauge pressure	527 psi
Brine flow	2.1 gpm
Product flow FM3	0.27 gpm
Calculated product flow	29.0 gph
Normalized flow	50.5 gph
Pressure gauge #1	31 psi
Pressure gauge #3	32 psi
Microfilter delta pressure	1 psi
Product water TDS	51 ppm
Product water pH	6.9
Product turbidity	0.74 NTU
Product chlorine level	6.4 ppm
Raw water TDS	33 ppm
Raw water pH	6.0
Raw water turbidity	30.1 NTU
Raw water temperature	7.3°C

SECTION IV
CONCLUSIONS

The Engineering Evaluation of the MEMTEC Small ROWPU was completed March 1990, after which both Units 1 and 2 were shipped to the Republic of Panama for tropic testing at the TTS. As delivered to Belvoir, the two MEMTEC Small ROWPUs were found to be acceptable in that they did not fail any of the criteria listed in the Quality Assurance Test (see objective 1, page 2). The engineering evaluation fully prepared the Project Engineer, water treatment NCO, and test director to initiate freshwater and seawater purification operations in Panama and provided a working understanding of the MEMTEC Small ROWPU (see objective 2, page 2). And finally, 85.2 total hours were logged on Unit 1 and 55.1 hours logged on Unit 2 (see objective 3, page 2).

SECTION V
RECOMMENDATIONS

1 Due to the failure of the submersible pump during the Seawater Test, a redesign is recommended to ensure that the pump wiring is effectively protected from exposure to the source water.

2 The air compressor supplied by MEMTEC did not have a National Electric Manufacture Association (NEMA) 4 rating. Although this was a requirement of contract DAAK70-89-C-0076, it was not included as an item for acceptance or rejection under the Quality Assurance Tests. To ensure that the air compressor and all other components delivered under future procurements can be safely operated outdoors and in the rain, this requirement must be included as a basis for acceptance or rejection of the Small ROWPU System.

3 The commercial manuals are adequate, but it is recommended that they be revised to include instructions for operation on freshwater mode without the RO system, and typical values to be expected for pressures and flow rates during operations on seawater, brackish water, and freshwater (both with and without the RO module).

4 An attempt should be made to keep aluminum parts away from the caustic cleaning solution to prevent the aluminum from dissolving.

APPENDIX A. USSOUTHCOM REQUEST FOR WATER PURIFICATION SUPPORT AND OPERATIONAL NEEDS STATEMENT

DEPARTMENT OF THE ARMY
OFFICE OF THE DEPUTY CHIEF OF STAFF FOR OPERATIONS AND PLANS
WASHINGTON, DC 20310 - 04

REPLY TO ATTENTION OF

16 JUN 1988

DAMO-FDL

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Request for Water Purification Support

1. References:

a. Memo, US SOUTHCOM, dated 2 May 88, subject as above.

b. Water Resource Management Action Group (WRMAG) #12 Meeting at Fort Belvoir, 3-5 May 88.

2. IAW Para 3-5c(2) and Para 3-9, AR 71-9 (Materiel Objectives and Requirements, 20 Feb 87), the ONS (enclosure 1) is approved provided comments in the attached DA Form 2028 (enclosure 2) are incorporated. A RCC is not required if procurement is NDI, requiring minimal or no modifications.

3. HQ AMC is requested to:

a. Procure prototypes using SOUTHCOM funds.

b. Test prototypes with user and develop acquisition strategy to meet FY 89/FY 90 fielding date.

4. As discussed in reference b, Type Classification is not required if the following criteria (Ref para 1-8e, AR 70-61) are met.

a. Commercial items authorized only by JTDA/TDA.

b. No standard items in system will satisfy requirement.

c. Requirement only for requesting unit.

d. Responsibility for logistical support (repair parts/ maintenance services) with user.

5. Manpower/force structure assessment. No additional personnel are authorized.

6. Training assessment. No special training requirements exist as discussed in reference b.

DAMO-FDL
SUBJECT: Request for Water Purification Support

7. US SOUTHCOM agrees with above plan for providing water purification support.

8. HQDA DAMO-FDL POC is Mr. Eddie Craig, AV 225-3261.

2 Encls

WILSON A. SHOFNER
Major General, GS
Assistant Deputy Chief of Staff
for Operations and Plans,
Force Development and Integration

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HQDA DALO-TSE, WASH, DC

OPERATIONAL NEEDS STATEMENT
USSOUTHCOM REQUIREMENT FOR WATER PURIFICATION

1. Problem.

a. The U. S. national strategy for dealing with Low Intensity Conflict advocates that indirect applications of U.S. military power are the most appropriate and cost effective ways to achieve national goals. Within the context of USSOUTHCOM the national goals have been defined as promotion of democracy, fostering economic development, strengthening dialogue and diplomacy within and among Latin American countries, and contributing to defensive capabilities that allow progress without debilitating external interference. The indirect application of military power toward these goals directly translates to security assistance in the form of small task forces. These small task forces perform a variety of assistance missions to include disaster relief, search and rescue, road building, counter-narcotic support, training support, civil-military activities, combined exercises, and peace keeping.

b. Currently assigned water purification/production capabilities of the USSOUTHCOM components are either fixed facilities or large vehicle mounted units requiring dedicated air transport to position them for water support of the deployed task forces. These systems are not suitable for supporting multiple 50-150 personnel tasks forces deployed throughout the theater on a routine basis. They are large, bulky, require a prime mover or special load handling equipment, and have a production capacity beyond the needs of an single task force. Yet, there are insufficient systems to support multiple task forces. USSOUTHCOM needs water purification units which are designed to support 50-150 personnel.

2. Justification. Water purification equipment used to support deployed theater task forces are frequently augmentation assets from CONUS units. As a minimum, this augmentation requires a single C-130 aircraft to transport the unit, personnel, and supplies to the area of operation. Minimum cost for this augmentation airlift is $24,000. Moreover, the availability of support personnel, equipment, and supplies to maintain production is often a problem. Even when augmented, the borrowed systems are no better suited to support the small task forces than the limited organic systems. The same problems exist - too heavy, too bulky, too much capacity, no flexibility, etc.

3. System Characteristics.

a. Required.

(1) Minimum acceptable output is 85 gallons per hour in salt water.

(2) Four man lift of system or individually configured components.

(3) Movable on the ground (components or system) by one man.

(4) Placed into operation in one hour.

(5) Air transportable by C-130 aircraft or CH-47 Chinook helicopter without reconfiguration.

(6) Sling loadable by UH-1 without reconfiguration.

(7) No special skill or training required of operator. A 94820 (cook) ~~can operate perform operator maintenance on the system after eight hours of training.~~ will be trained to operate and perform operator Maintenance on the system

(8) System operates off of standard military generators.

b. Desirable.

(1) System is configured as one unit requiring no assembly other than connection of hoses.

(2) System operates off of standard 115V AC/DC current.

(3) System alerts operator to problems or required maintenance.

4. Operational Concept. The water purification units will be included in the task organizations and employed by the 250 to 300 small joint task forces which are deployed each year throughout Latin America on a variety of assistance missions.

5. Organizational Concept. The water purification units will be assigned within USARSO for property accountability and non-periodic maintenance. The units will be receipted to the logistical support element of deployed joint task forces as required to support missions of USSOUTHCOM throughout the area of responsibility.

6. Procurement Objectives. The systems will be used to support operational requirements. A total of 12 to 18 units, depending on the specific purification rates (85-250 gallons per hours) will be required to fulfill the total USSOUTHCOM requirement.

7. Support requirements. The water purification units will require small power generators and water storage tanks for the purified water. Water pumps may also be required depending on the design characteristics of the system.

8. Availability. A market survey conducted by BDM under Contract No. DABT 60-86-C-1360 indicates that the USSOUTHCOM requirement could be fulfilled by several US manufactured commercial models through off-the-shelf procurement on a short-notice basis.

9. Recommendation. That ADEA and BRDEC be tasked to procure and evaluated prototype models for fulfilling the USSOUTHCOM requirement and refining concepts of employment. Subsequent to this evaluation, 18 systems should be procured to meet the USSOUTHCOM need.

PURCHASE DESCRIPTION
WATER PURIFICATION UNIT
SMALL UNIT OPERATIONS
REVERSE OSMOSIS

1. SCOPE

1.1 Scope. This purchase description defines a reverse osmosis water purification unit, having a net potable water production of 150 GPH, for use in small unit operations. The effluent water shall meet field Army drinking water standards as stated in TB MED 577. The unit shall operate 20 hours per day from fresh (0-1500 ppm NaCl) brackish (1501-15,000 ppm NaCl) or salt water, (15,001 - 37,000+ ppm NaCl) sources. The unit shall be capable of treating the above types of water containing turbidities up to 150 nephelometic turbidity units (NTU's). It shall be capable of operation using a standard military 5 KW generator. The unit shall not be required to withstand electromagnetic pulsations (EMP), nuclear, biological, and chemical (NBC) agent contamination or decontamination of chemical agents (DECON). The unit requires no special camouflage requirements. The unit shall comply with noise standards found in MIL-STD-1474 and shall be capable of operation at altitudes of up to 14,000 feet. The unit shall be operable in an outdoor tropic environment to include heavy rain. The unit shall be simple to operate and require no maintenance other than basic operator support during missions lasting as long as 60 days. It shall require no special tools for maintenance at the operator

level. The unit shall have a system support package which will allow operation for two weeks without resupply. The unit shall be skid mounted and protected such that the units can be stacked at least 3 high. It must be transportable in one or more loads by vehicle as small as a 1/4 ton Jeep. The unit may be built in sections or subsystems which consist of (1) raw water intake, (2) fresh [redacted] treatment segment capable of stand alone operation, (3) [redacted] treatment system operable in tandem with the fresh water Brackish and system and (4) storage and distribution system which may be gravity operated. Maximum weight for each section of the unit shall not exceed 150 pounds. Each section shall be portable by not more than four (4) persons. The unit shall be capable of being assembled in a maximum of 1 hour and operated by unskilled personnel. The unit, without reconfiguration, shall be air transportable by a C-130 or CH-47 Chinook helicopter. The unit, without reconfiguration, must be able to be sling loaded under a UH-1 helicopter. [redacted] Soldiers shall be trained operate and maintain the unit. [redacted] The contractor shall provide all spare and repair parts necessary to operate the unit for a period of five years. The unit shall be fabricated from compatible materials that are inherently corrosion resistant or have been treated to provide protection against the various forms of corrosion and deterioration that may be encountered in any of the applicable operating and storage environments to which the unit may be exposed. The unit shall be capable of complete drainage.

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS

For use of this form, see AR 310-1; the proponent agency is the US Army Adjutant General Center.

Use Part II (reverse) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/Supply Manuals (SC/SM).

DATE: 3 Jun 88

TO: (Forward to proponent of publication or form) (Include ZIP Code)
Commander
U.S. Army TRADOC
ATTN: ATCD-SL
Fort Monroe, VA 23651-5000

FROM: (Activity and location) (Include ZIP Code)
HQDA DCSOPS
ATTN: DAMO-FDL
WASHINGTON, D.C. 20310-0460

PART I - ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER	DATE	TITLE
	2 Mar 88	Operational Needs Statement USSOUTHCOM Requirement for Water Purification

ITEM NO.	PAGE NO.	PARAGRAPH	LINE NO.*	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON (Provide exact wording of recommended changes, if possible).
1	2	2a(7)	2			CHANGE: "can operate...hours of training" TO READ: will be trained to operate, and perform operator maintenance on the system. REASON: The designated operator of this equipment may be in an isolated area and his skills in operating and maintaining this equipment will be the difference in providing water for the task force. Since the operator does not have a specific MOS, the trainee must be able to put the equipment into operation and maintain it which may require more or less than eight hours of training.
	Purchase Description					
2	5	3.1	27			DELETE: "and brackish" REASON: The system should have a stand alone fresh treatment segment and a separate segment for treating brackish and/or salt water.
3	5	3.1	28			CHANGE: "(3) salt water..." TO READ: "(3) brackish and salt water..." REASON: The system should have a stand alone fresh treatment segment and a separate segment for treating brackish and/or salt water.
4	5	3.1	37			CHANGE: "An unskilled.....training." TO READ: "An unskilled soldier shall be trained to operate and maintain the unit." REASON: The designated operator of this equipment may be in an isolated area and his skills in operating and maintaining this equipment will be

*Reference to line numbers within the paragraph or subparagraph.

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION	SIGNATURE
EDWARD L. CRAIG, GM-13 System Integrator	AV [illegible] (202) 695-[illegible]	Edward L Craig

DA FORM 2028 REPLACES DA FORM 2028 DEC 80 WHICH WILL BE USED

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS

For use of this form, see AR 310-1; the proponent agency is the US Army Adjutant General Center.

Use Part II (reverse) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/Supply Manuals (SC/SM).

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						the difference in providing water for the task force. Since the operator does not have a specific MOS, the trainee must be able to put the equipment into operation and maintain it which may require more or less than eight hours of training.

*Reference to line numbers within the paragraph or subparagraph.

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION	SIGNATURE
EDWARD L. CRAIG, GM-13 System Integrator	AV(225) (202) 695-3261	Edward L Craig

DA FORM 2028 REPLACES DA FORM 1045, DEC 68, WHICH WILL BE USED.

APPENDIX B. ACCEPTANCE CRITERIA FROM CONTRACT DAAK70-89-C-0076

SECTION E
INSPECTION AND ACCEPTANCE

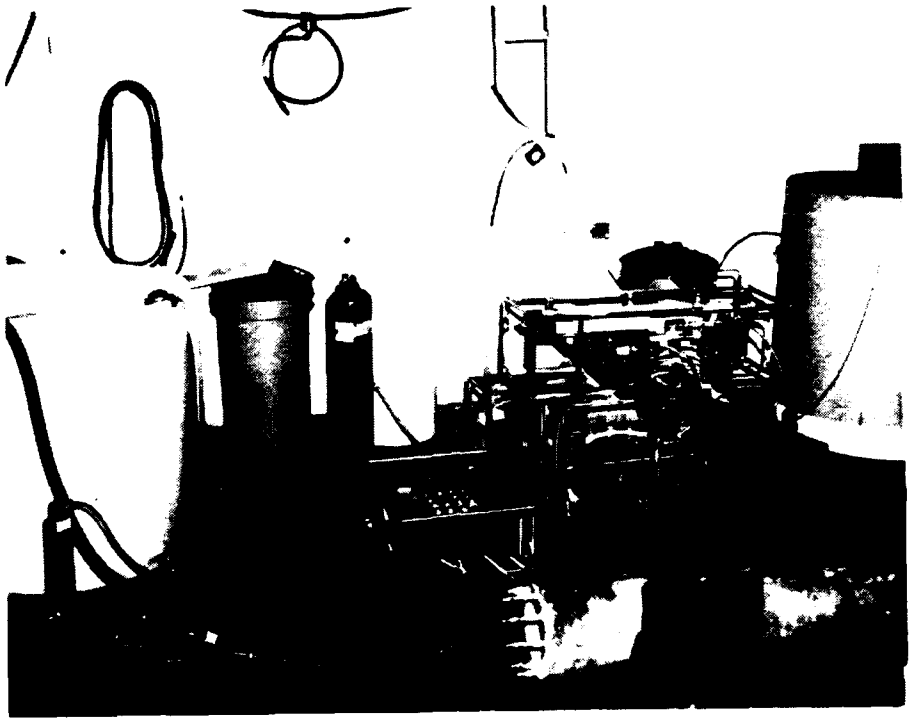
E.1 CLIN 0001 - Final inspection and acceptance of contract line items number (CLIN) 0001, shall be made at Fort Belvoir, VA, by an authorized representative of the Contract Officer. The government shall require a period not to exceed thirty (30) calendar days after receipt of delivery for final inspection and acceptance. The basis for acceptance shall be compliance with the requirements and standards of section C, and passing the Quality Assurance Test set forth at E.1.1.

E.1.1 Quality Assurance Test (6 hours). Each ROWPU shall be hydraulically tested using saltwater (35,000 tds at 77 deg F) for not less than 6 hours. Evidence of any of the following conditions shall constitute failure of this test:

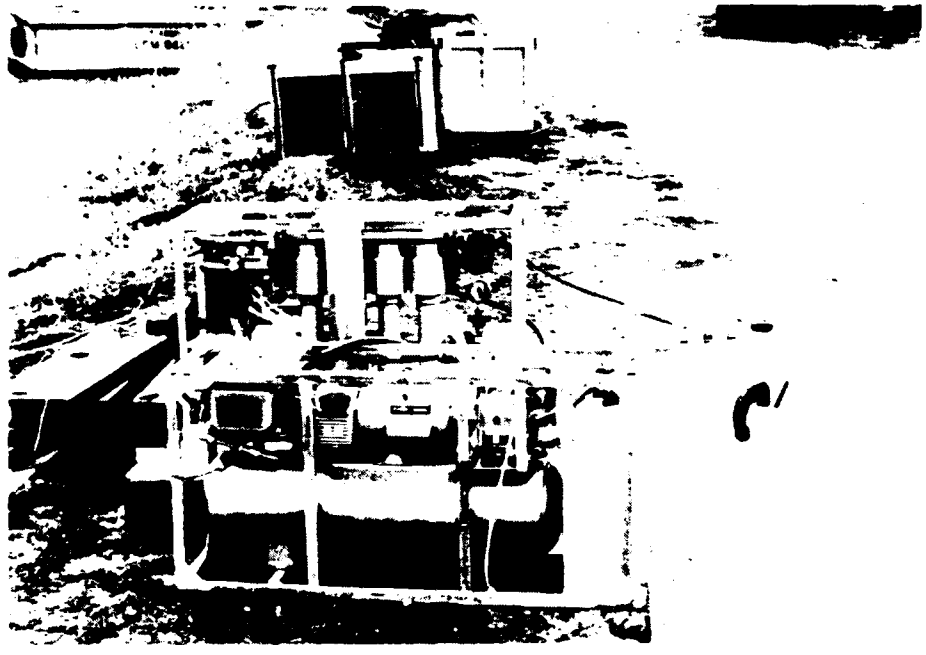
a. Leaks at any weld seam or any connection.
b. Light, or any switch fails to operate.
c. Valves fail to operate properly.
d. Mechanical or electrical failure of any component or part.

Upon completion of the test, the ROWPU shall be flushed with fresh chlorine-free water for a period of 10 minutes. Chemical tanks are to be filled with fresh water. Control knobs on the chemical feed pumps are to be set for maximum flow. The ROWPU is to be operated in a normal manner for 10 minutes. After flushing, all drain and vent valves are to be opened and left open. The ROWPU will then be prepared for movement as instructed by the technical manuals.

APPENDIX C. TESTING PHOTOGRAPHS

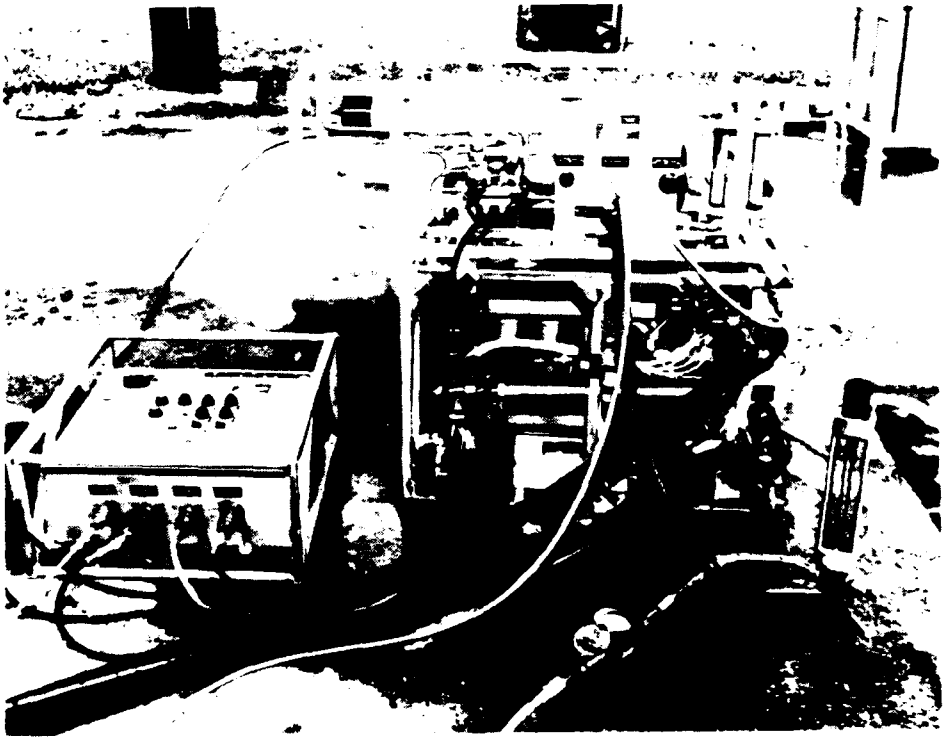


MEMTEC Limited, Engineering Evaluation, Seawater and Quality Assurance Tests

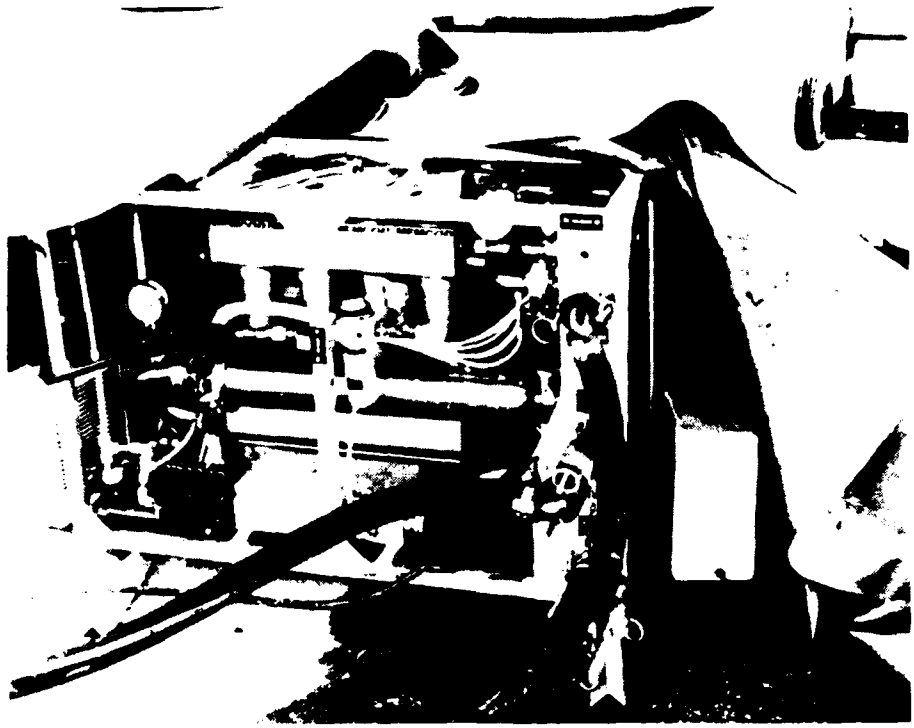


MEMTEC Limited, Engineering Evaluation, River Test

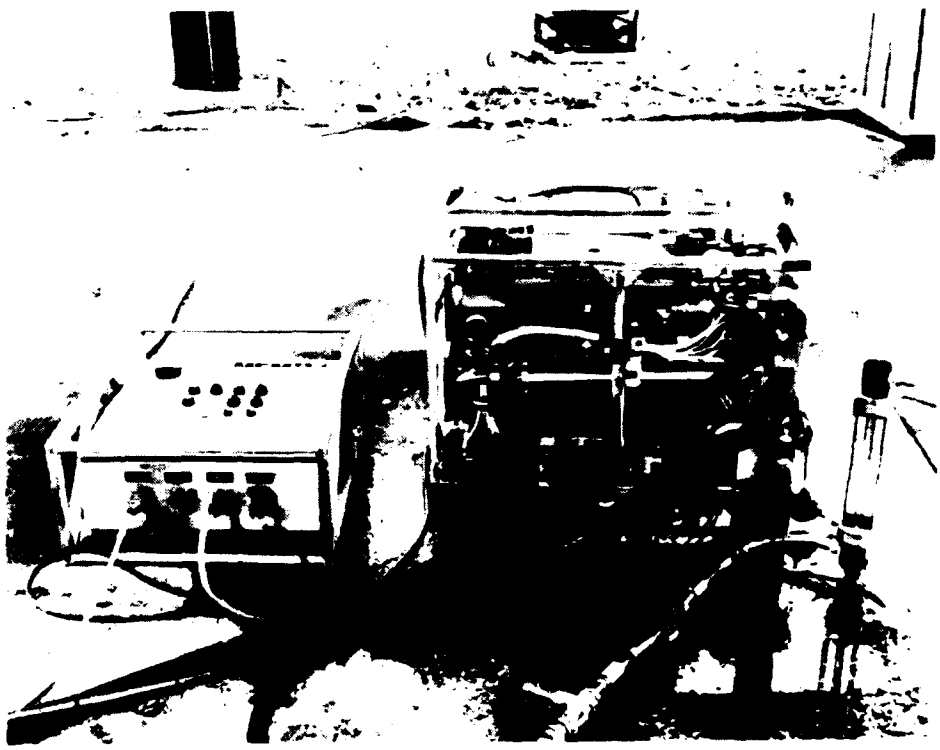
MEMTEC Limited, Engineering Evaluation, River Test



MEMTEC Limited, Engineering Evaluation, Pond Test



MEMTEC Limited, Engineering Evaluation, Pond Test



MEMTEC Limited, Engineering Evaluation, Pond Test

APPENDIX D. HOURLY DATA FOR SEAWATER TEST

MEMTEL ENGINEERING EVALUATION SALT WATER TEST DATA

DATE	TIME	FLOW TOTALIZER F1 (gal)	HOURLY FLOW	CUMLATIVE HOURLY FLOW (gal)	TOTAL UNIT TIME (hr)	PRESSURE GAUGE #5 (psi)	NET DRIVING PRESSURE	OSMOTIC PRESSURE (psi)	BRINE FLOW FM2 (gpm)	PRODUCT FLOW FM3 (gpm)	EXTERNAL PRODUCT FM1	CALC PROD FLOW (gph)	NORMALIZE FLOW (gph)	PRESSURE GAUGE #1 (psi)
2/12/90	715	80352			12.3									
	800	80378	26	26	13.6	890	477	398	1.9	0.30	88	30.2	38.6	26
	900	80385	7	33		890	443	432	1.9	0.26	88	30.2	41.3	26
	1000	80417	32	65	14.6	900			1.8	0.25	88	30.2		26
	1300	80427	10	75	15.3	820	407	398	1.9	0.28	93	31.9	43.9	26
	1400	80450	23	98	16.0	800	387	398	1.9	0.26	91	31.2	44.2	27
	1500	80481	31	129	17.1	780	367	398	1.9	0.26	90	30.9	44.4	27
	1600	80514	33	162	18.1	780	356	409	1.9	0.28	94	32.2	46.1	27
	1700	80543	29	191	19.1	760	336	409	2.0	0.26	91	31.2	46.0	26
2/13/90	630	80557	14	205	19.2	790	372	403	2.0	0.26	89	30.5	42.7	26
	700	80566	9	214	19.5	780	373	392	2.0	0.26	91	31.2	44.6	26
	800	80586	20	234	20.5	750	326	409	1.9	0.26	89	30.5	47.4	26
	900	80625	39	273	21.5	720	296	409	1.9	0.26	89	30.5	50.7	27
	1000	80644	19	292	22.4	740	327	398	1.9	0.26	89	30.5	44.9	27
	1100	80675	31	323	23.4	740	316	409	2.0	0.26	89	30.5	44.8	27
	1200	80705	30	353	24.4	710	286	409	2.0	0.26	88	30.2	48.5	27
	1300	80735	30	383	25.4	720	296	409	2.0	0.26	91	31.2	47.8	27
	1600	80749	14	397	26.0	730	294	421	2.0	0.26	89	30.5	47.4	26
	1700	80768	19	416	26.9	740	327	398	1.9	0.28	93	31.9	44.6	26
2/14/90	710	80774	6	422	27.2	780	333	432	1.9	0.28	95	32.6	47.3	26
	800	80809	35	457	28.0	720	296	409	2.0	0.26	88	30.2	48.0	27
	900	80838	29	486	29.0	720	296	409	2.0	0.26	89	30.5	47.6	28
	1000	80867	29	515	30.0	720	307	398	2.0	0.26	92	31.5	46.4	28
	1100	80887	20	535	31.0	700	276	409	2.0	0.26	89	30.5	49.0	28
	1200	80915	28	563	32.0	700	287	398	2.0	0.26	89	30.5	45.8	28
	1300	80944	29	592	33.0	700	264	421	2.0	0.26	90	30.9	51.0	28
	1400	80972	28	620	34.0	700	276	409	2.0	0.26	90	30.9	46.7	28
	1500	81001	29	649	35.0	700	276	409	2.0	0.26	90	30.9	46.0	27
	1600	81030	29	678	36.0	700	276	409	2.0	0.26	91	31.2	47.2	27
	1700	81060	30	708	37.0	700	287	398	2.0	0.26	92	31.5	44.5	27
	1800	81099	39	747	38.0	700	276	409	2.0	0.27	93	31.9	46.5	27
	1900	81128	29	776	39.0	680	267	398	2.1	0.26	87	29.8	44.6	27
	2000	81146	18	794	40.0	680	267	398	2.2	0.26	88	30.2	45.0	28
2/15/90	715	81149	3	797	40.1	720	318	387	2.0	0.26	90	30.9	42.6	26
	800	81166	17	814	40.7	720	307	398	2.0	0.26	90	30.9	44.1	28
	900	81198	32	846	41.7	700	287	398	2.0	0.26	88	30.2	45.5	27
	1000	81223	25	871	42.7	700	287	398	2.0	0.26	89	30.5	45.8	28
	1100	81253	30	901	43.7	700	287	398	2.0	0.26	89	30.5	46.0	28
	1200	81281	28	929	44.7	700	287	398	2.0	0.26	90	30.9	46.2	28
	1300	81319	38	967	45.7	700	287	398	2.0	0.26	89	30.5	45.3	28
	1400	81340	21	988	46.7	700	287	398	2.0	0.26	89	30.5	45.1	28
	1500	81366	26	1014	47.7	700	287	398	2.0	0.26	89	30.5	44.5	28
	1600	81396	30	1044	48.7	700	287	398	2.0	0.26	90	30.9	43.8	27
	1700	81425	29	1073	49.7	680	267	398	2.0	0.26	89	30.5	47.9	27
2/16/90	740	81437	12	1085	49.8	700	287	398	2.0	0.25	88	30.2	48.1	27
	800	81447	10	1095	50.2	710	252	443	2.0	0.26	88	30.2	54.4	27
	900	81466	19	1114	51.1	710	365	330	2.0	0.26	89	30.5	37.1	27
	1000	81496	30	1144	52.1	710	365	330	2.0	0.26	89	30.5	36.9	27
	1100	81524	28	1172	53.1	710	354	341	2.0	0.26	88	30.2	37.0	27
	1200	81551	27	1199	54.1	710	354	341	2.0	0.26	88	30.2	36.6	27
	1300	81580	29	1228	55.1	710	354	341	2.0	0.26	88	30.2	36.2	27
TOTALS			1228		42.8									
AVERAGE						732	310	390	2.0	0.26	90	30.7	44.1	27

MEMTEC ENGINEERING EVALUATION SALT WATER TEST DATA

DATE	TIME	PRESSURE GAUGE #3 (psi)	CMF TRANS-MEMBRANE PRESSURE	PRODUCT TDS (ppm)	PRODUCT PH	RAW TDS (ppm)	RAW PH	TEMP CORRECTION FACTOR	RAW TEMP DEG C	GENERATOR HOURS
2/12/90	715									12.2
	800	26	0	270	7.7	35000	8.5	1.3	16.6	13.6
	900	26	0	310	7.6	38000	7.3	1.3	16.8	14.0
	1000	26	0	340						10.8
	1300	26	0	240	8.1	35000	7.4	1.2	19.3	11.5
	1400	27	0	240	7.8	35000	7.8	1.1	20.0	12.2
	1500	27	0	350	7.9	35000	7.0	1.1	21.3	13.3
	1600	26	1	270	7.8	36000	8.3	1.1	22.6	14.3
	1700	27	-1	270	8.5	36000	8.1	1.0	23.6	15.2
2/13/90	630	26	0	320	7.7	35400	8.4	1.1	21.7	15.6
	700	26	0	250	8.0	34500	8.1	1.1	21.0	16.1
	800	26	0	270	7.6	36000	7.2	1.1	22.8	17.2
	900	27	0	270	7.8	36000	7.2	1.0	23.9	18.1
	1000	27	0	270	7.0	35000	6.5	1.0	24.7	19.1
	1100	27	0	290	8.9	36000	7.5	1.0	26.1	20.0
	1200	27	0	310	7.8	36000	7.5	1.0	26.5	21.0
	1300	27	0	330	8.0	36000	7.3	1.0	27.0	21.9
	1600	27	-1	350	7.6	37000	8.3	1.0	26.7	24.0
	1700	26	0	290	7.7	35000	8.2	1.0	26.6	25.0
2/14/90	710	27	-1	265	8.4	38000	8.1	1.0	24.5	25.4
	800	27	0	280	7.4	36000	6.9	1.0	25.5	26.2
	900	28	0	290	7.8	36000	7.1	1.0	26.3	27.2
	1000	28	0	290	7.9	35000	7.1	0.9	27.2	28.2
	1100	28	0	310	7.8	36000	7.3	0.9	28.0	29.2
	1200	28	0	320	7.8	35000	7.3	0.9	29.1	30.2
	1300	28	0	320	8.0	37000	7.3	0.9	28.5	31.2
	1400	28	0	330	7.3	36000	7.8	0.9	30.5	32.2
	1500	27	0	340	7.1	36000	7.8	0.9	31.2	33.2
	1600	27	0	340	7.6	36000	7.5	0.9	30.5	34.2
	1700	27	0	340	7.6	35000	7.4	0.8	31.8	35.2
	1800	27	0	340	7.3	36000	7.6	0.8	32.2	36.2
	1900	28	-1	350	8.0	35000	7.6	0.8	32.5	37.2
	2000	28	0	340	8.4	35000	7.6	0.8	32.6	38.2
2/15/90	715	26	0	300	7.2	34000	7.6	0.9	28.3	38.3
	800	28	0	290	7	35000	7.6	0.9	28.3	39.1
	900	27	0	290	7	35000	7.7	0.9	28.9	40.1
	1000	28	0	310	7.2	35000	7.7	0.9	29.1	41.1
	1100	28	0	290	7.3	35000	7.7	0.9	28.9	42.1
	1200	28	0	290	7.3	35000	7.6	0.9	29.2	43.2
	1300	28	0	300	7.2	35000	7.6	0.9	29.6	44.0
	1400	28	0	300	7.2	35000	7.5	0.9	29.8	45.1
	1500	28	0	300	7.3	35000	7.5	0.9	30.4	46.0
	1600	27	0	300	7.3	35000	7.6	0.9	31.6	46.9
	1700	27	0	350	5.6	35000	5.7	0.9	30.3	47.9
2/16/90	740	27	0	360	5.7	35000	5.8	1.0	26.6	48.3
	800	27	0	330	5.7	33000	5.8	1.0	27.0	48.6
	900	27	0	330	5.9	29000	5.7	0.9	27.8	49.6
	1000	27	0	340	5.6	29000	5.5	0.9	28.1	50.4
	1100	27	0	370	5.7	30000	5.5	0.9	28.8	51.6
	1200	27	0	400	5.7	30000	5.2	0.9	29.3	52.6
	1300	27	0	390	4.7	30000	5.0	0.9	29.7	53.6
TOTALS										44.6
AVERAGE		27	0	311	7.3	34998	7.3	0.9	26.4	

APPENDIX E. HOURLY DATA FOR RIVER TEST (WITHOUT RO MODULE)

MEMTEC RIVER TESTING FEB 1990 (FRESH WATER HIGH TURBIDITY with NO RO SKID)

DATE	TIME	FLOW TOTALIZER T1 (gal)	HOURLY FLOW	CUMLATIVE HOURLY FLOW (gal)	TOTAL UNIT TIME (hr)	EXTERNAL PRODUCT FM1	CALC PROD FLOW (gph)	PRESSURE GAUGE #1 (psi)	PRESSURE GAUGE #3 (psi)	CMF TRANS-MEMBRANE PRESSURE	PRODUCT TDS (ppm)	PRODUCT PH	PRODUCT TRUBIDITY (NTU)	RAW TDS (ppm)	RAW PH
2/22/90	700	82099	0	0	73.4	3.5	63.6	23	22	1	120	7.3	0.13	130	7.4
	800	82148	49	49	74.4	3.1	56.4	23	22	1	120	7.4	0.11	130	7.5
	900	82186	38	87	75.4	2.4	43.6	23	23	0	130	7.5	0.13	130	7.4
	1000	82213	27	114	76.0	0.4	7.3	23	24	-1	130	7.5	0.11	130	7.4
	1100	82236	23	137	77.0	1.9	34.5	24	23	1	125	7.3	0.13	125	7.4
	1400	82283	47	184	78.0	3.7	67.3	22	22	0	120	7.4	0.09	120	7.4
	1500	82320	37	221	78.9	0.8	14.5	24	24	0	125	7.4	0.13	120	7.3
	1700	82358	38	259	79.7	3.7	67.3	22	22	0	120	7.6	0.10	120	7.4
2/23/90	700	82379	21	280	80.4	3.7	67.3	22	22	0	120	7.7	0.18	120	7.3
	800	82453	74	354	81.3	4.2	76.4	23	22	1	120	6.9	0.65	120	7.4
	900	82531	78	432	82.3	4.3	78.2	22	22	0	120	7.4	0.67	125	7.4
	1000	82614	83	515	83.3	4.1	74.5	22	22	0	120	7.0	0.44	125	7.2
	1100	82689	75	590	84.2	4.1	74.5	22	22	0	125	7.5	0.16	125	7.1
	1200	82767	78	668	85.2	4.1	74.5	22	22	0	120	7.1	0.17	125	7.4
AVERAGE			668		11.8										
TOTAL							57.1	23	22	0	123	7.4	0.23	125	7.4

MEMTEC RIVER TESTING FEB 1990 (FRESH WATER HIGH TURBID

DATE	TIME	RAW TRUBIDITY (NTU)	RAW TEMP DEG C	GENERATOR HOURS
2/22/90	700	11.6	8.4	23.9
	800	10.6	8.3	24.7
	900	17.7	8.5	24.7
	1000	16.8	8.5	26.4
	1100	14.9	9.0	27.4
	1400	10.9	9.5	28.8
	1500	10.5	9.5	29.8
	1700	16.4	8.8	31.4
2/23/90	700	10.7	9.5	32.3
	800	10.4	9.7	33.3
	900	10.5	9.8	34.2
	1000	10.1	10.0	35.3
	1100	10.1	10.1	36.2
	1200	9.6	10.5	37.1
AVERAGE				13.2
TOTAL		12.2	9.3	

APPENDIX F HOURLY DATA FOR RIVER TEST (WITH RO MODULE)

MEMTEC RIVER TESTING FEB 1990 (FRESH WATER HIGH TURBIDITY with RO SKID)

DATE	TIME	FLOW TOTALIZER T1 (gal)	HOURLY FLOW	CUMLATIVE HOURLY FLOW (gal)	TOTAL UNIT TIME (hr)	PRESSURE GAUGE 85 (psi)	NET DRIVING PRESSURE	OSMOTIC PRESSURE (psi)	BRINE FLOW FM2 (gpm)	PRODUCT FLOW FM3 (gpm)	EXTERNAL PRODUCT FM1	CALC PROD FLOW (gph)	NORMALIZE FLOW (gpm)	PRESSURE GAUGE 81 (psi)	PRESSURE GAUGE 83 (psi)
2/20/90	800	81592	0	0	55.6	430	413	1.8	1.30	0.34	86	29.5	61.9	20	0
	900	81617	25	25	56.5	380	364	1.5	1.90	0.26	87	29.8	73.2	22	22
	1000	81646	29	54	57.6	420	404	1.4	1.84	0.26	88	30.2	64.8	22	22
	1100	81689	43	97	58.6	380	364	1.4	1.90	0.26	85	29.1	72.2	22	21
	1200	81705	16	113	59.5	360	344	1.4	1.84	0.26	85	29.1	70.5	18	18
	1300	81736	31	144	60.5	380	364	1.4	1.80	0.28	89	30.5	67.9	20	20
	1400	81760	24	168	61.3	380	364	1.3	1.80	0.26	90	30.9	68.1	21	21
	1500	81790	30	198	62.3	400	384	1.4	1.80	0.28	92	31.5	66.0	22	20
	1600	81827	37	235	63.3	370	354	1.4	1.75	0.28	88	30.2	67.6	18	17
	1700	81847	20	255	64.3	380	364	1.4	1.72	0.26	89	30.5	65.9	18	17
2/21/90	800	81848	1	256	64.5	380	364	1.4	1.94	0.24	88	30.2	73.3	22	22
	900	81873	25	281	65.5	400	384	1.4	1.83	0.26	88	30.2	68.8	22	22
	1000	81900	27	308	66.5	400	384	1.3	1.88	0.26	88	30.2	67.8	22	22
	1100	81926	26	334	67.5	400	384	1.3	1.84	0.27	90	30.9	68.7	22	22
	1200	81953	27	361	68.4	400	384	1.3	1.84	0.26	89	30.5	66.4	22	22
	1300	81980	27	388	69.4	400	384	1.3	1.84	0.26	90	30.9	66.9	22	22
	1400	82007	27	415	70.4	380	364	1.3	1.88	0.26	89	30.5	68.2	22	22
	1500	82032	25	440	71.4	380	364	1.3	1.86	0.26	88	30.2	66.9	22	22
	1600	82059	27	467	72.4	380	364	1.4	1.86	0.26	88	30.2	66.0	22	22
	1700	82084	25	492	73.3	380	364	1.4	1.86	0.26	87	29.8	65.8	22	21
TOTAL			492		17.7										
AVERAGE						389	373		1.81	0.27		30.3	68.1	21	20

MEMTEC RIVER TESTING FEB 1990 (FRESH WATER HIGH TURBIDITY with RO SKID)

DATE	TIME	CMF TRANS-MEMBRANE PRESSURE	PRODUCT TDS (ppm)	PRODUCT PH	PRODUCT TRUBIDITY (NTU)	RAW TDS (ppm)	RAW PH	RAW TRUBIDITY (NTU)	RAW TEMP DEG C	TEMP CORRECTION FACTOR	GENERATOR HOURS
2/20/90	800	12	13.0	7.5	0.20	160	8.6	10.0	7.7	1.8	4.6
	900	0	5.0	8.0	0.50	130	7.1	10.8	7.1	1.9	5.6
	1000	0	4.0	7.7	0.30	120	6.8	74.0	7.7	1.8	6.6
	1100	1	5.0	7.6	0.13	120	7.0	70.0	6.9	1.9	7.7
	1200	0	5.0	7.5	0.10	120	7.0	86.0	8.6	1.7	8.5
	1300	0	3.0	8.0	0.17	120	6.9	45.3	9.2	1.7	9.5
	1400	0	3.0	8.3	0.13	110	7.2	37.0	9.4	1.7	10.4
	1500	2	2.5	7.2	0.09	120	7.0	27.0	9.4	1.7	11.4
	1600	1	4.5	8.0	0.08	119	7.1	29.0	9.7	1.7	12.3
	1700	1	2.5	8.1	0.13	119	7.2	28.6	9.9	1.6	13.3
2/21/90	800	0	8.0	8.2	0.11	120	7.5	15.0	7.3	1.9	14.5
	900	0	4.0	8.0	0.18	120	6.7	13.5	7.5	1.8	15.6
	1000	0	4.0	7.4	0.10	110	6.1	47.9	7.8	1.8	16.6
	1100	0	3.0	8.0	0.12	110	6.8	24.1	8.0	1.8	17.6
	1200	0	3.0	8.2	0.10	110	7.2	33.2	8.5	1.8	18.5
	1300	0	3.0	8.0	0.08	110	7.3	21.2	8.6	1.7	19.5
	1400	0	4.0	8.2	0.08	110	7.1	18.3	9.1	1.7	20.5
	1500	0	4.0	8.2	0.09	110	7.3	20.2	9.3	1.7	21.5
	1600	0	2.0	7.7	0.11	120	7.4	16.0	9.6	1.7	22.5
	1700	1	2.3	8.0	0.10	120	7.2	15.1	9.4	1.7	23.4
TOTAL											18.8
AVERAGE		1	4.5	7.9	0.15	119	7.1	34.0	8.4	1.8	

APPENDIX G. HOURLY DATA FOR POND TEST (WITHOUT RO MODULE)

MEMTEC UNIT ENGINEERING EVALUATION POND TEST WITH NO RO UNIT

DATE	TIME	FLOW TOTALIZER T1 (gal)	HOURLY FLOW	CUMLATIVE HOURLY FLOW (gal)	TOTAL UNIT TIME (hr)	EXTERNAL PRODUCT FM1	CALC PROD FLOW (gph)	PRESSURE GAUGE #1 (psi)	PRESSURE GAUGE #3 (psi)	CMF TRANS-MEMBRANE PRESSURE	PRODUCT TDS (ppm)	PRODUCT PH	PRODUCT TURBIDITY (NTU)	RAW TDS (ppm)	RAW PH
2/26/90	830	82807	0	0	19.0	5.0	90.9	31	31	0	30	6.2	0.13	30	6.5
	900	82862	55	55	19.5	5.0	90.9	31	32	1	30	6.0	0.09	30	6.2
	1000	82938	76	131	20.5	5.0	90.9	32	32	0	30	5.8	0.03	30	6.3
	1100	83023	85	216	21.6	4.9	89.1	30	30	0	25	5.7	0.50	30	6.5
	1200	83104	81	297	22.5	4.9	89.1	31	31	0	25	5.6	0.37	30	6.2
	1300	83189	85	382	23.5	4.9	89.1	31	31	0	25	5.6	0.07	30	6.3
	1400	83275	86	468	24.6	4.9	89.1	32	32	0	25	5.5	0.07	30	6.3
	1500	83360	85	553	25.6	4.9	89.1	32	32	0	25	5.5	0.07	30	6.3
	1600	83446	86	639	26.6	4.9	89.1	32	32	0	25	5.6	0.07	30	5.7
2/27/90	700	83465	19	658	26.9	4.9	89.1	31	30	-1	25	5.5	0.18	30	6.1
	800	83543	78	736	27.9	4.9	89.1	31	31	0	25	5.6	0.16	30	6.2
	900	83626	83	819	28.8	4.9	89.1	31	31	0	25	5.6	0.12	30	6.0
	1000	83716	90	909	29.9	4.9	89.1	31	31	0	25	5.7	0.06	30	6.3
	1100	83800	84	993	30.9	4.9	89.1	32	32	0	28	5.6	0.13	32	6.3
	1200	83885	85	1078	31.9	4.9	89.1	32	32	0	28	5.6	0.09	30	6.3
	1300	83974	89	1167	32.9	4.9	89.1	32	32	0	28	5.7	0.10	30	6.0
	1400	84061	87	1254	34.0	4.8	87.3	32	32	0	26	5.4	0.09	30	6.3
	1500	84157	96	1350	35.0	4.9	89.1	32	32	0	28	5.7	0.11	30	6.1
	1600	84232	75	1425	36.0	4.8	87.3	32	32	0	28	5.6	0.09	30	6.6
	1700	84310	78	1503	37.0	4.8	87.3	32	32	0	27	5.7	0.15	30	5.8
2/28/90	830	84329	19	1522	37.3	5.0	90.9	31	31	0	25	5.8	0.12	32	5.7
	900	84377	48	1570	37.8	5.0	90.9	32	32	0	27	5.5	0.19	30	6.0
	1000	84475	98	1668	38.9	5.0	90.9	32	32	0	50	6.3	0.57	30	6.1
	1100	84566	91	1759	39.9	5.0	90.9	32	32	0	50	6.1	0.26	30	6.2
	1200	84667	101	1860	40.9	5.0	90.9	32	32	0	43	5.9	0.52	32	6.3
	1300	84760	93	1953	41.9	5.0	90.9	32	32	0	40	5.6	0.41	30	6.3
	1400	84858	98	2051	42.9	4.9	89.1	32	32	0	28	5.7	0.18	30	6.1
	1500	84949	91	2142	43.9	4.9	89.1	32	32	0	28	5.6	0.15	30	6.3
	1600	85047	98	2240	45.0	4.9	89.1	32	32	0	28	5.8	0.17	30	5.8
	1700	85144	97	2337	46.0	4.9	89.1	32	32	0	28	5.7	0.15	32	5.9
TOTAL			2337		27.0										
AVERAGE							89.5	32	32	0	29	5.7	0.18	30	6.2

MEMTEC UNIT ENGINEERING EVALUATION POND TEST WITH NO RO UNIT

DATE	TIME	RAW TURBIDITY (NTU)	RAW TEMP DEG C	GENERATOR HOURS
2/26/90	830	15.8	4.2	13.4
	900	14.9	3.5	13.9
	1000	21.6	4.3	14.9
	1100	23.4	4.4	15.9
	1200	24.3	5.1	16.9
	1300	24.3	5.6	17.9
	1400	23.1	5.4	18.9
	1500	24.4	5.5	20.0
	1600	23.8	5.3	21.0
2/27/90	700	19.9	4.5	21.6
	800	21.2	4.1	22.5
	900	21.1	4.0	23.5
	1000	21.8	4.7	24.6
	1100	22.4	4.9	25.6
	1200	22.8	4.9	26.6
	1300	22.7	5.1	27.6
	1400	24.3	5.3	28.6
	1500	25.2	5.2	29.7
	1600	27.1	5.5	30.7
	1700	27.1	5.7	31.6
2/28/90	830	22.1	4.7	32.5
	900	22.0	4.5	33.0
	1000	23.8	5.4	34.1
	1100	24.7	6.5	35.1
	1200	24.7	6.6	36.1
	1300	25.4	6.9	37.1
	1400	26.6	7.5	38.1
	1500	27.2	7.8	39.1
	1600	27.6	7.8	40.2
	1700	28.3	7.1	41.2
TOTAL				27.8
AVERAGE		23.5	5.4	

APPENDIX H. HOURLY DATA FOR POND TEST (WITH RO MODULE)

MEMTEC UNIT ENGINEERING EVALUATION POND TEST WITH RO UNIT

DATE	TIME	FLOW TOTALIZER T1 (gal)	HOURLY FLOW	CUMLATIVE HOURLY FLOW (gal)	TOTAL UNIT TIME (hr)	PRESSURE GAUGE #5 (psi)	NET DRIVING PRESSURE	OSMOTIC PRESSURE (psi)	BRINE FLOW FM2 (gpm)	PRODUCT FLOW FM3 (gpm)	EXTERNAL PRODUCT FM1	CALC PROD FLOW (gph)	NORMALIZE FLOW (gph)	PRESSURE GAUGE #1 (psi)
3/1/90	700	85169	0	0	46.4	580	564.7	0.3	2.30	0.30	88	30.2	52.8	30
	800	85197	28	28	47.3	540	524.6	0.4	2.20	0.31	89	30.5	56.9	31
	900	85227	30	58	48.3	580	564.6	0.4	2.20	0.30	87	29.8	51.9	31
	1000	85255	28	86	49.3	540	524.6	0.4	2.20	0.30	89	30.5	55.7	31
	1100	85286	31	117	50.3	540	524.6	0.4	2.20	0.30	89	30.5	53.2	31
	1200	85314	28	145	51.4	530	514.7	0.3	2.20	0.30	90	30.9	52.2	31
	1300	85343	29	174	52.3	520	504.6	0.4	2.20	0.30	89	30.5	51.2	31
	1400	85373	30	204	53.3	520	504.7	0.3	2.20	0.30				31
	1500	85393	20	224	54.1	480	464.7	0.3	2.20	0.30	88	30.2	55.8	30
	1600	85424	31	255	55.1	500	484.7	0.3	2.20	0.31	89	30.5	54.6	31
3/5/90	730	85438	14	269	55.4	550	534.5	0.5	2.04	0.31	89	30.5	54.7	30
	800	85442	4	273	55.8	525	509.5	0.5	2.00	0.32	96	32.9	58.8	31
	900	85477	35	308	56.8	530	514.6	0.4	2.10	0.30	86	29.5	53.7	30
	1000	85494	17	325	57.8	560	544.6	0.4	2.10	0.31	90	30.9	51.1	31
	1100	85513	19	344	58.4	560	545.0	0.0	2.10	0.32	87	29.8	47.7	31
	1200	85541	28	372	59.4	530	514.6	0.4	2.10	0.30	90	30.9	51.0	30
	1300	85570	29	401	60.4	520	504.6	0.4	2.10	0.30	87	29.8	48.5	31
	1400	85601	31	432	61.4	505	489.6	0.4	2.10	0.30	88	30.2	51.0	31
	1500	85630	37	469	62.4	500	484.7	0.3	2.10	0.30	87	29.8	50.7	31
	1600	85659	21	490	63.4	450	434.7	0.3	2.15	0.30	89	30.5	57.3	30
	1700	85689	30	520	64.4	500	484.7	0.3	2.15	0.30	89	30.5	51.0	30
TOTAL			520		18.0									
AVERAGE						527	511.3	0.4	2.15	0.30		29.0	50.5	31

MEMTEC UNIT ENGINEERING EVALUATION POND TEST WITH RO UNIT

DATE	TIME	PRESSURE GAUGE #3 (psi)	CMF TRANS-MEMBRANE PRESSURE	PRODUCT TDS (ppm)	PRODUCT PH	PRODUCT TURBIDITY (NTU)	PRODUCT CHLORINE (ppm)	RAW TDS (ppm)	RAW PH	RAW TURBIDITY (NTU)	RAW TEMP DEG C	TEMP CORRECTIO FACTOR	GENERATOR HOURS
3/1/90	700	31	1	8	5.0	0.18		30	6.2	25.7	5.1	2.1	42.1
	800	32	1	390	10.9	6.43	0.4	35	5.9	25.9	5.3	2.1	42.9
	900	32	1	260	10.9	2.16	1.5	35	5.2	27.3	5.2	2.1	43.9
	1000	32	1	34	6.3	0.62	0.1	35	6.5	27.8	5.7	2.0	44.9
	1100	32	1	100	9.5	1.02	10.0	35	6.3	32.4	6.6	1.9	45.9
	1200	32	1	70	8.9	0.48	10.0	30	6.6	33.3	7.6	1.8	46.9
	1300	32	1	20	6.3	0.27	10.0	35	6.7	30.8	8.2	1.8	47.9
	1400	32	1	10	6.4	0.17	5.0	30	5.9	34.6	8.1	1.8	49.0
	1500	30	0	10	6.4	1.60	5.0	30	6.3	35.5	7.9	1.8	50.0
	1600	32	1	10	6.2	0.21	3.0	30	6.0	35.4	7.7	1.8	51.0
3/5/90	730	32	2	40	7.6	0.20	10.0	40	5.9	23.3	5.7	2.0	
	800	32	1	25	7.1	0.17	10.0	45	6.0	27.3	6.7	1.9	52.3
	900	31	1	15	6.3	0.19	10.0	32	5.9	28.6	6.1	2.0	53.3
	1000	32	1	17	6.4	0.22	10.0	32	6.1	29.7	6.9	1.9	54.3
	1100	32	1	12	6.0	0.12	10.0		5.9	31.1	7.6	1.8	55.0
	1200	31	1	17	6.2	0.17	10.0	31	6.0	31.7	8.1	1.8	55.9
	1300	32	1	9	6.0	0.12	3.0	32	6.0	30.0	8.9	1.7	56.9
	1400	32	1	6	5.4	0.15	0.1	32	6.0	29.9	8.7	1.7	58.0
	1500	32	1	5	6.0	0.74		30	5.5	31.1	8.8	1.7	58.9
	1600	31	1	4	5.2	0.13		30	5.9	30.5	9.0	1.7	60.0
	1700	31	1	10	6.7	0.17		30	5.8	30.2	9.2	1.7	61.0
TOTAL													18.9
AVERAGE		32	1	51	6.9	0.74	6.4	33	6.0	30.1	7.3	1.9	

APPENDIX I. MATERIAL SAFETY DATA SHEET FOR PROPYLENE GLYCOL

UNION CARBIDE

UNION CARBIDE CORPORATION

Specialty Chemicals Division

MATERIAL SAFETY DATA SHEET

EFFECTIVE DATE: 08/30/88

Union Carbide urges each customer or recipient of this MSDS to study it carefully to become aware of and understand the hazards associated with the product. The reader should consider consulting reference works or individuals who are experts in ventilation, toxicology, and fire prevention, as necessary or appropriate to use and understand the data contained in this MSDS.

To promote safe handling, each customer or recipient should: (1) notify its employees, agents, contractors and others whom it knows or believes will use this material of the information in this MSDS and any other information regarding hazards or safety; (2) furnish this same information to each of its customers for the product; and (3) request its customers to notify their employees, customers, and other users of the product of this information.

I. IDENTIFICATION

PRODUCT NAME: UCAR Food Freeze 35

CHEMICAL NAME: Propylene glycol (phosphate inhibited)

CHEMICAL FAMILY: Glycols

FORMULA: $CH_3CH(OH)CH_2OH$ MOLECULAR WEIGHT: 76.1

SYNONYMS: Mixture

CAS # and CAS NAME: Not applicable
Not applicable (Mixture)

II. PHYSICAL DATA (Determined on typical material)

BOILING POINT, 760 mm Hg: 162 C (324 F) FREEZING POINT: POUR POINT: -51 C (-59 F)

SPECIFIC GRAVITY(H_2O = 1): 1.052 at 20/20 C

VAPOR PRESSURE AT 20°C: ~0.7 mm Hg (~0.09 kPA)

VAPOR DENSITY (air = 1): ~2.4 (Volatile portion) SOLUBILITY IN WATER by wt: 100

EVAPORATION RATE (Butyl Acetate = 1): 0.06 (Volatile portion)

APPEARANCE AND ODOR: Clear colorless liquid; odorless

III. INGREDIENTS

MATERIAL	%	TLV (Units)	HAZARD
Propylene glycol	~95.5+	None established	See Section V
Dipotassium hydrogen phosphate	~ 2.0	None established	See Section V
Demineralized Water	~ 2.5	None established	See Section V

EMERGENCY PHONE NUMBER: 1-800-UCC-HELP (Number available at all times)

UNION CARBIDE CORPORATION
Specialty Chemicals Division
39 Old Ridgebury Road, Danbury, CT. 06817-0001

PRODUCT NAME: UCAR Food Freeze 35

IV. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (test method(s)):	210 F (99 C), Pensky-Martens Closed Cup ASTM D 93 240 F (116 C), Cleveland Open Cup ASTM D 92
FLAMMABLE LIMITS IN AIR, % by volume	LOWER: 2.6 Propylene glycol UPPER: 12.5 Propylene glycol
EXTINGUISHING MEDIA:	Apply alcohol-type or all-purpose-type foam by manufacturer's recommended techniques for large fires. Use CO2 or dry chemical media for small fires.
SPECIAL FIRE FIGHTING PROCEDURES:	Use self-contained breathing apparatus and protective clothing.
UNUSUAL FIRE AND EXPLOSION HAZARDS:	None

V. HEALTH HAZARD DATA

TLV AND SOURCE:	None established by ACGIH or OSHA.

EFFECTS OF SINGLE OVEREXPOSURE:

SWALLOWING:	No evidence of adverse effects from available information.
SKIN ABSORPTION:	No evidence of adverse effects from available information.
INHALATION:	No evidence of adverse effects from available information.
SKIN CONTACT:	Contact with bare skin may cause minimal irritation, seen as mild local redness.
EYE CONTACT:	May cause minimal irritation, seen as excess redness of the conjunctiva.

EFFECTS OF REPEATED OVEREXPOSURE:
Repeated skin contact may result in the development of an allergic skin reaction in a very small proportion of individuals.

MEDICAL CONDITIONS AGGRAVATED BY OVEREXPOSURE:
A knowledge of available toxicology information and of the physical and chemical properties of the material suggests that overexposure is unlikely to aggravate existing medical conditions.

SIGNIFICANT LABORATORY DATA WITH POSSIBLE RELEVANCE TO HUMAN HEALTH HAZARD EVALUATION: None currently known.

OTHER EFFECTS OF OVEREXPOSURE:
May promote absorption of other chemicals.

EMERGENCY AND FIRST AID PROCEDURES:

SWALLOWING:	If conscious, give two glasses of water and induce vomiting. Call a

PRODUCT NAME: UCAR Food Freeze 35

	physician immediately.
SKIN:	Wash with soap and water.
INHALATION:	Remove to fresh air.
EYES:	Flush eyes with water thoroughly and continuously for 15 minutes.
NOTES TO PHYSICIAN:	There is no specific antidote. Treatment of overexposure should be directed at the control of symptoms and the clinical condition.

VI. REACTIVITY DATA

STABILITY: Stable

CONDITIONS TO AVOID: None

INCOMPATIBILITY (materials to avoid):
None

HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS:
Burning can produce carbon monoxide and carbon dioxide, and trace amounts of oxides of potassium and phosphorus.

HAZARDOUS POLYMERIZATION: Will Not Occur

CONDITIONS TO AVOID: None

VII. SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED:
Small spills could be flushed with large amounts of water. Larger spills should be collected for disposal.

WASTE DISPOSAL METHOD: Incinerate in a furnace or otherwise dispose of in accordance with applicable Federal, State, and local requirements. See Section IX.

VIII. SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (specify type):
None expected to be needed.

VENTILATION: General (mechanical) room ventilation is expected to be satisfactory.

PROTECTIVE GLOVES: Polyvinyl chloride-coated

EYE PROTECTION: Safety glasses

OTHER PROTECTIVE EQUIPMENT:
Eye bath and safety shower.

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IX. SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE:

WARNING: CAUSES EYE AND SKIN IRRITATION.
MAY CAUSE ALLERGIC SKIN REACTION.
Avoid contact with eyes, skin, and clothing.
Wash thoroughly after handling.
FOR INDUSTRY USE ONLY

OTHER PRECAUTIONS: At very low concentrations in water, this product is readily biodegradable in a biological wastewater treatment system.

NOTE ----
The opinions expressed herein are those of qualified experts within Union Carbide Corporation. We believe that the information contained herein is current as of the date of this Material Safety Data Sheet. Since the use of this information and of these opinions and the conditions of the use of the product are not within the control of Union Carbide Corporation, it is the user's obligation to determine the conditions of safe use of the product.

Prepared by: Dr. W. F. Gorham

Date: 07/19/88
Revision Date: 08/31/88
PC: 71695
F NUMBER: B0270

Printed in USA

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